Section 33 of the NPRM actually may be adequate and appropriate for LMDS in the 40.5-42.5 GHz band since it indicates that e.i.r.p. levels above 16 dBW will be considered on a case-by-case basis subject to coordination with affected licensees. The resulting homogeneity between systems would minimize interference between licensees. On the other hand, the Commission might find it appropriate to consider a higher limit, at least during rain, in order to accommodate a wider range of system parameters and, in particular, power control.

III SHARING OF THE 60.4-61.4 GHz BAND BY SPACEBORNE PASSIVE SENSORS AND PROPOSED TERRESTRIAL USE IS FEASIBLE

The Commission requests comment on whether terrestrial use of the 60.4-61.4 GHz band would interfere with planned spaceborne passive sensor measurements of atmospheric temperature[17]. NASA has analyzed the sharing potential and concludes that sharing is feasible.

The frequency range from 50 to 65 GHz is of particular interest to the Earth environmental science and meteorological communities because of the presence of unique atmospheric oxygen absorption lines that are located in this region of the spectrum. Spaceborne passive sensor measurements in the vicinity of these lines are used to develop atmospheric temperature profiles. Judicious selection of the measurement frequencies determines the altitudes in the atmosphere at which temperature measurements are obtained. The 60.4-61.4 GHz band is used for mesospheric temperature measurements at heights between approximately 45

17 NPRM at para. 12.

km and 70 km. The Commission's NPRM proposes to designate the 59-64 GHz band for use by unlicensed devices. The band 60.4-61.4 GHz is located within this band.

The passive sensor measurements will obtain temperature data from the mesosphere. We have assumed the use of 'pushbroom sensors' in our analysis. This new class of passive sensor can achieve greater measurement sensitivity but is more susceptible to interference than conventional scanned sensors[18]. The interference threshold of pushbroom sensors is -166 dBW in a reference bandwidth of 100 MHz. The antenna and orbit parameters of the Advanced Microwave Sounding Unit (AMSU) were assumed for this analysis[19]. The AMSU has an antenna with a 15 cm diameter having a gain of 36 dBi and producing a pixel having a diameter at nadir of 49 km. AMSU will be placed in orbit at an altitude of 850 km.

The Commission proposes that unlicensed devices (except vehicular radars) be limited to a peak power density of 200 nanowatts/cm^2 at a distance of 3 meters from the antenna. As pointed out in the NPRM, this power density is comparable to an e.i.r.p. of 0.25 w.

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18 Recommendation ITU-R SA.1029, "Interference Criteria for Satellite Passive Remote Sensing", specifies a permissible interference level of -166 dBW in a reference bandwidth of 100 MHz for pushbroom sensors in the frequency range of 50 to 66 GHz compared to -161 dBW for conventionally scanned sensors.

19 The first AMSU will be placed in orbit on a NOAA satellite during 1995. It will not have a capability to take measurements in the 60.3-61.3 GHz band. This feature will be added to future versions of the AMSU.

Zenith attenuation exceeds 200 dB at the peaks of the oxygen absorption lines between 60.3 and 61.3 GHz[20].

The interference level caused by a single transmitter with parameters conforming to those proposed in the NPRM can be readily calculated to be equal to -357 dBW compared to the sensor interference threshold of -166 dBW. Up to 1.26×10^{19} of these transmitters could be located in the main beam of an improved AMSU sensor without causing interference.

It is readily apparent that the proposed terrestrial use of the 59-64 GHz band will not interfere with passive sensor operations in the 60.3-61.3 GHz band.

IV. COMMENTS ON ALLOCATION OF 116-117 GHz and 122-123 GHz FOR UNLICENSED DEVICES

The proposed use of 116-117 GHz and 122-123 GHz bands for unlicensed devices gives NASA a great deal of concern. Both of these bands fall within the 116-126 GHz band allocated for the Earth exploration-satellite (passive) and space research (passive) services. There is an oxygen absorption line at 118.7 GHz which is much weaker than those in the vicinity of 60 GHz but still of use for passive spaceborne sensing. Our analysis shows that, in contrast to the situation at 60 GHz, only 1586 0.25 w transmitters directed at zenith would reach the interference threshold of our reference sensor design. We think it is probable that more than this number of unlicensed transmitters could be found in areas of 7500 km^2, the area on the Earth subtended by the sensor antenna mainbeam.

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20 CCIR Report 719-2.

We recommend that either alternative bands, outside bands allocated for passive sensing, be chosen for unlicensed devices in place of the 116-117 GHz and 122-123 GHz bands or that the transmitter power in these two bands be limited to -16 dBW in order to achieve compatibility.

V. PROPAGATION IMPAIRMENTS IN THE 10 TO 100 GHz RANGE

There is increasing use of frequencies above 10 GHz for all types of radio communications as evidenced by the Commission's release of an NPRM for use of frequencies above 40 GHz. These frequencies offer wider bandwidths, less congestion, and smaller components than bands at lower frequencies. These advantages can be rapidly offset, however, unless propagation impairments are understood and taken into account during system design. Important frequency impairments above 10 GHz, and even more so at frequencies above 40 GHz include rain attenuation, attenuation by atmospheric gasses including water vapor and oxygen, the effects of clouds and clear air, and tropospheric scintillation.

NASA has carried out a propagation research program spanning more than 2 decades to provide satellite system designers with information about the impairments that affect Earth-space communications. At the present time there is an active set of propagation experiments being conducted with the ACTS satellite to expand knowledge of the propagation environment at 20 and 30 GHz.

One product produced by the NASA program is a handbook on propagation effects for satellite systems design[21]. While this handbook is directed particularly to satellite system designers, most of the information applies equally to terrestrial communications links. We believe that the contents of this document can be valuable to the Commission as it plans how to allocate, license and use frequencies above 40 GHz. For that reason, we are appending the NASA handbook to these comments.

VI. CONCLUSION

WHEREFORE, the foregoing considered, NASA urges the Commission to:

- Take advantage of this NPRM to resolve the problems surrounding its proposals to establish an LMDS under CC Docket No. 92-297 by designating 40.5-42.5 GHz for LMDS in lieu of 27.5-29.5 GHz;

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21 NASA Reference Publication 1082(04), Fourth Edition, "Propagation Effects Handbook for Satellite Systems Design - A Summary of Propagation Impairments on 10 to 100 GHz Satellite Links With Techniques for System Design", Louis J. Ippolito, 1989.

- Either move the bands proposed for unlicensed devices at 116-117 GHz and 122-123 GHz out of the frequency band 116-126 GHz band allocated for passive sensors in the Earth exploration-satellite and space research services or limit the power of unlicensed devices in these bands to -16 dBW;

Respectively submitted,

By:
Charles T. Force
Associate Administrator for
Space Communications
National Aeronautics and Space
Administration

January 30, 1995

APPENDIX 2

REPLY COMMENTS OF THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FILED UNDER ET DOCKET NO. 94-124

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of

Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications	))))	ET Docket No. 94-124 RM-8308

REPLY COMMENTS OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Charles T. Force
Associate Administrator
for Space Communications
National Aeronautics and Space Administration

March 1, 1995

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SUMMARY

There was overwhelming support among commenters for the Commission's proposals to open for commercial development and use a portion of the frequency bands above 40 GHz. There was broad consensus that the proposals will provide the American public with access to new products and communications services, provide new opportunities for American business and industry; and, promote new jobs and economic growth in the United States.

A vast majority of responses offered evidence that the technology needed to exploit frequencies above 40 GHz is available today and expressed the opinion that the Commission's proposed rules, if implemented, will spur rapid development of even more advanced technology in the near future.

There was general agreement that the 40.5-42.5 GHz band should be allocated for licensed service and that rules suitable for LMDS in the 27.5-29.5 GHz band are appropriate in this band.

The comments confirm NASA's belief that the proposals in the subject NPRM provide the basis for solving the incompatibilities that would exist in the 27.5-29.5 GHz band were that band to be allocated to both the Fixed-Satellite Service (FSS) and to a new Local Multipoint Distribution Service ("LMDS") as contemplated in CC Docket No. 92-297. The effect of the Commission's proposals in the instant NPRM would be to create a band at 40.5-42.5 GHz with virtually the same conditions as that proposed at 27.5-29.5 GHz. The same 2 GHz of bandwidth would be established, to be licensed in the same 1000 MHz blocks. The

propagation environment at 40 GHz is similar to that in the nearby 28 GHz band as are the equipment parameters. Only the name has changed from LMDS to LMWS.

The Commission's proposal for commercial use of the 40.5-42.5 GHz band is the key to resolving the severe incompatibility problems that exist between the FSS and the LMDS in the 27.5-29.5 GHz band. Use of the 40.5-42.5 GHz band for LMDS in lieu of the 27.5-29.5 GHz band would result in a win-win situation for the American public and for American industry. The satellite industry would be free at 27.5-29.5 GHz to build on the technologies pioneered by NASA's (Advanced Communications Technology Satellite (ACTS) to fill an essential role in the National/Global Information Infrastructure (NII/GII). At the same time, LMDS could be developed without interference from the FSS in the 40.5-42.5 GHz band. American industry would have the opportunity to participate in two global markets rather than none since the FSS is allocated in the 27.5-29.5 GHz band on a global basis and the functionally equivalent European version of LMDS is being developed in the 40.5-42.5 GHz band.

The evidence is in. Industry has spoken and given the Commission ample evidence that the conditions are favorable and the equipment is available to implement LMDS in the 40.5-42.5 GHz band.

In view of the outstanding benefits to the nation that would be realized from implementation of LMDS in the 40.5-42.5 GHz band in lieu of the 27.5-29.5 GHz band, the proper action for the Commission to take is now clear: LMDS should be allocated in the 40.5-42.5 GHz band where it can develop without interference from the fixed-satellite service (FSS) and the 27.5-29.5 GHz

band should continue to be used for innovative, new services provided by satellites.

The Commission has received comments that contain proposals to allocate additional or alternative frequency bands to those contained in its NPRM. In addition, some comments advocate higher e.i.r.p. limits than those proposed in the NPRM. There is now the need to rationalize the proposals and to optimize the potential to accommodate the requirements of all services in the frequency bands above 40 GHz.

The frequency range from 50 to 65 GHz is of particular interest to the Earth environmental science and meteorological communities because of the presence of unique atmospheric oxygen absorption lines that are located in this region of the spectrum. Spaceborne passive sensor measurements in the vicinity of these lines are used to develop atmospheric temperature profiles. Judicious selection of the measurement frequencies determines the altitudes in the atmosphere at which temperature measurements are obtained. Recognizing the value of this singular scientific resource, WARC-79 allocated the bands 50.2-50.4 GHz and 51.4-59.0 GHz to the Earth exploration-satellite (passive) service to be used to obtain data for weather forecasting and climate studies. Some of these allocations, specifically 50.2-50.4 GHz and 54.25-58.2 GHz, are shared with active radio services. Sharing studies prior to the 1979 WARC, based on characteristics for as yet undeveloped equipment extrapolated from similar equipment in lower bands, indicated that sharing should be feasible. Actual developments since 1979 have deviated from these projections with the result that certain adjustments in allocations to optimize use of this spectrum for the benefit

of all of the allocated services would be in order.

Allocations in the frequency range between 50.2 GHz and 71 GHz should be adjusted to accommodate all spectrum users. We believe that the following allocation realignments in the 50.2-71 GHz range would enable interference-free atmospheric temperature measurements of vital importance to understanding the world's weather and climate while removing any need for constraints on the parameters of the emerging fixed and inter-satellite systems that will use frequencies above 40 GHz:

- provide exclusive allocations for the Earth exploration-satellite (passive) service in the currently shared bands between 50.2-50.4 GHz and 54.25-56 GHz;

- make an allocation to the Earth exploration-satellite (passive) service in the band 60.3-61.3 GHz;

- move the current ISS allocation in the 54.25-58.2 GHz band, except for the small band from 56.9-57.0 GHz which is required for use by existing Government non-LEO ISS systems, into the range 65-71 GHz;

- limit ISS use of the band 60.3-61.3 GHz to systems other than crosslinks between LEO satellites;

- share the currently exclusively passive band 58.2-59 GHz between the Earth exploration-satellite (passive) service and the fixed and mobile services;

- when the foregoing actions have been completed, delete the Earth exploration-satellite (passive) service from the band 51.4-52.6 GHz in favor of allocations to the fixed and mobile services.

We note the proposal in the NPRM to allocate 94.7-95.7 GHz for vehicular radars on an exclusive basis. The responses to the NPRM include essentially unanimous support for exclusive allocations for vehicular radars. To adhere to the advice

that vehicular radars should occupy exclusive bands while accommodating a need for operation of spaceborne cloud radars between 94 and 95 GHz, we recommend shifting the band for vehicular radar up in frequency by 300 MHz into the band 95-96 GHz.

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of

Amendment of Parts 2 and 15 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications	))))	ET Docket No. 94-124 RM-8308

REPLY COMMENTS OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration ("NASA") hereby replies to the comments filed in response to the Commission's Notice of Proposed Rulemaking (NPRM) issued in the above-captioned proceeding.

I. INTRODUCTION

There was overwhelming support among commenters for the Commission's proposals to open for commercial development and use a portion of the frequency bands above 40 GHz. There was broad consensus that the proposals will provide the American public with access to new products and communications services, provide new opportunities for American business and industry; and, promote new jobs and economic growth in the United States. A vast majority of responses offered evidence that the technology needed to exploit frequencies above 40 GHz is available today and expressed the opinion that the Commission's proposed rules, if implemented, will spur rapid development of even more advanced

technology in the near future. There was general agreement that the 40.5-42.5 GHz band should be allocated for licensed service and that rules suitable for LMDS in the 27.5-29.5 GHz band are appropriate in this band. Only 2 proponents of LMDS at 28 GHz argued that 40.5-42.5 GHz is not a suitable band for LMDS. In view of the outstanding benefits to the nation that would be realized from implementation of LMDS in the 40.5-42.5 GHz band in lieu of the 27.5-29.5 GHz band, the proper action for the Commission to take is now clear: LMDS should be allocated in the 40.5-42.5 GHz band where it can develop without interference from the fixed-satellite service (FSS) and the 27.5-29.5 GHz band should continue to be used for innovative, new services provided by satellites.

The Commission received a number of comments that suggested alternative and additional frequency bands to those that the Commission has proposed to make available for use. In addition, some comments advocate higher e.i.r.p. limits than those proposed in the NPRM. As explained below, there is a need to realign allocations above 40 GHz in a way that will accommodate the needs of all users of the spectrum. The instant NPRM creates an important opportunity to improve access to, and efficient use of spectrum above 40 GHz.

II. OVERWHELMING SUPPORT EXISTS FOR OPENING FREQUENCY BANDS ABOVE 40 GHz FOR ALLOCATION AND USE

Our analysis of the comments that the Commission has received in response to its proposals to open frequency bands above 40 GHz for allocation and use shows overwhelming support for the proposals. Of 40 comments, 38 voiced approval while only one, CellularVision,[1] opposed

[1] See comments of CellularVision at 4.

allocation of frequencies above 40 GHz. Of the twenty two sets of comments received specifically on the 40.5-42.5 GHz band, 20 voiced support for its allocation for LMDS services. Only two, CellularVision and Texas Instruments, rejected this action as impractical[2,3]. We submit that the majority has the facts to support their position and the Commission can confidently move forward to allocate LMDS in the 40.5-42.5 GHz band.

III. THE COMMENTS CONFIRM THAT 40.5-42.5 GHz IS SUITABLE FOR DEVELOPMENT OF LMDS

The comments submitted by many of the most elite telecommunications and technology development companies in the country confirm that technology is readily available to develop LMDS in the 40.5-42.5 GHz frequency band.

For example, AT&T observes with respect to the 40.5-42.5 GHz band that:

> .... Low cost millimeter wave techniques can be used over distances of several kilometers, despite the fading impact caused by rain.[4]

Similarly, Pacific Bell and Telesis Technologies Laboratory writes:

> The 40.5-42.5 GHz band is particularly attractive because of the wide bandwidth. We recommend that the Commission permit at least 1 GHz of this band to be allocated for a service in the

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2 id. at 5.

3 Texas Instruments states that they support making frequencies above 40 GHz available for commercial development but states its view that a 40 GHz LMDS system is economically unattractive.

4 Comments of AT&T at p. 2.

> nature of local multipoint distribution service ("LMDS"). The block allocated for LMDS-like service should be equally divided between two carriers. We further recommend that satellite operations not be permitted in the band allocated to LMDS. As the Commission knows, the difficulties encountered in the rulemaking at 28 GHz provide ample evidence of the need for additional spectrum for LMDS unencumbered by satellite uses.[5]

Avant-Garde expresses interest in LMDS at 40.5-42.5 GHz and reports that it is already providing "last-mile" service using the 38.6-40.0 GHz band which ".... exhibits propagation characteristics similar to other bands above 40 GHz that the Commission is proposing to make available ...."

Specifically, Avant-Garde reports that:

> Avant-Garde has begun providing service using this 38 GHz band spectrum. Thus, Avant-Garde can confirm that commercial use of millimeter wave transmission is practical.[6]

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5 Comments of Pacific Bell and Telesis Technologies Laboratory at p. 2.

6 Comments of Avant-Garde at p. 2.

Hewlett-Packard "strongly" supports "the establishment of 40.5-42.5 GHz as a licensed band for LMWS."[7] They confirm that:

> Solid state devices are available today that will provide powers of close to 1 watt at 40 GHz. The power capability will increase over the next few years.[8]

Further, Hewlett-Packard states that:

> Below [100 GHz], Monolithic Microwave Integrated Circuits (MMICs) based on submicron-gate III-V material FETs are practical and available.[9]

The Millimeter Wave Advisory Group has submitted comments that support the Hewlett-Packard views.

The Fixed Point-to-Point Communications Section, Network Equipment Division of the Telecommunications Industry Association (TIA) also "strongly supports the use of the 40.5-42.5 GHz band for LMDS applications as a replacement for the 28 GHz band."[10] Alcatel Network Systems, Inc. concurs with the TIA views[11] as does the Harris Corporation-Farinon Division[12].

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7 Hewlett-Packard comments at 3.

8 id. at 15.

9 id. at 11.

10 TIA comments at p. 9.

11 Alcatel Network Systems comments at p. 2.

12 Harris comments at p. 2.

Comments of Hughes Aircraft Company, Commercial Products Business Unit further verify that components are readily available for LMDS use at 40 GHz:

> Currently, commercially available millimeter wave power sources (either Gunn Oscillator or Gallium Arsinide monolithic integrated circuits (MMICs) amplifiers) are capable of generating a few hundreds of milliwatts in the frequency range of 40 up to 75 GHz, The power capability will further improve in the very near future. Further, antenna gains as high as 50 dBi are readily available. Thus, EIRPs as high as +50 dBW will be easily achievable.[13]

Rockwell International Corporation, a "diversified high technology company" also supports the view that "moving LMDS to the 40.5-42.5 GHz band is the Commission's best opportunity to resolve the ongoing spectrum management conflict in the 28 GHz band." GE Americom has filed similar comments.

TRW is another high technology company that has experience working at millimeter wave frequencies and comments that:

> TRW has been and continues to be one of the nation's primary developers of electronic equipment and hardware for the millimeter bands. Through its years of experience in this area, TRW has gained a thorough understanding of the properties and inherent strengths of the spectrum above 40 GHz that is proposed for allocation here. It can state with conviction that the technology that would drive LMDS at 28 GHz is not only available for 40 GHz, there is no appreciable cost difference.[14]

Endgate Technology Corporation, a major proponent of LMDS:

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13 Comments of Hughes Aircraft Company, Commercial Products Business Unit at 18.

14 Comments of TRW at p. 7. TRW goes on to state their view that, even neglecting the allocation problems at 28 GHz, there are superior prospects for terrestrial fiber-optic quality services at 40 GHz compared to the prospects at 28 GHz.

> ... believes that the 40.5-42.5 GHz band can be effectively used for wideband services and that .... the characteristics of both propagation and millimeter-wave equipment are conducive to a practical near-term implementation of either broadband local loop communication links or broadcast video distribution.[15]

Another advocate of LMDS, GHz Equipment Co. (GEC), an equipment manufacturer and systems integrator, characterizes itself as "a leader in millimeter wave technology". GEC states that its "research shows that services that can be accommodated in the 40.5-42.5 GHz spectrum include two-way interactive data and video networks linking schools, libraries, colleges, universities and other learning centers to the NII."[16] GEC goes on to state that their research confirms that the 40 GHz spectrum is well suited for economical, effective "last mile" delivery service to the home.[17] The Clarendon Foundation supports the views of GEC and reports that its research also confirms that the 40 GHz spectrum is well suited for economical, effective "last mile" delivery service.[18]

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15 Endgate comments at 2.

16 GHz Equipment Co. comments at II.

17 id.

18 Comments of Clarendon Foundation at II.

Teledesic Corporation advocates that LMDS be allocated at 40 GHz in lieu of 28 GHz. Teledesic has analyzed the feasibility of LMDS at 40 GHz in some detail and has concluded that:

> LMDS operation in the 41 GHz band is technically comparable to such operation in the K_a band and is readily achievable from both a propagation standpoint and an equipment standpoint.[19]

Hughes Communications Galaxy, Inc. also supports an LMDS allocation at 40 GHz in lieu of 28 GHz and has also carried out extensive studies of the feasibility of developing LMDS at 40 GHz. In particular, Hughes has investigated the propagation conditions at 40 GHz and finds "that there is little appreciable difference in LMDS performance between 28 and 40 GHz"[20] and that:

> Any minor differences that may occur would not significantly affect performance, and, if the operator so desired, could be mitigated through minor design or operational changes.[21]

NASA believes that the evidence is in. Industry has spoken and given the Commission ample evidence that the conditions are favorable and the equipment is available to implement LMDS in the 40.5-42.5 GHz band.

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19 Teledesic comments at C. Teledesic also provides characteristics of the LMDS-like systems under construction in Europe as further evidence that equipment needed to implement LMDS at 40 GHz exists today.

20 Hughes Galaxy comments at II.

21 id.

IV. EVIDENCE BELIES CELLULARVISION'S ASSERTION THAT LMDS IS NOT FEASIBLE AT 40.5-42.5 GHz

The CellularVision comments claim that there would be a major cost penalty, by a factor of 30-40, associated with implementation costs of LMDS at 40 GHz.[22] This claim is based on the analysis that CellularVision includes with its comments[23] which is at odds with information supplied to the Commission by U.S. industry. We must therefore question the CellularVision steadfast opposition to use of 41 GHz for LMDS in the face of overwhelming evidence that LMDS is viable at 41 GHz. We note that a probable reason lies in the tentative Commission decision in its first Notice of Proposed Rulemaking in this matter to grant Suite 12 (CellularVision) a pioneer's preference for LMDS at 28 GHz making it the only eligible applicant for one of the frequency blocks for its preferred service area[24].

Propagation considerations

CellularVision claims that ".... rainfall attenuation at 40 GHz will be so severe that it will jeopardize the viability of an LMDS system."[25] However, NASA demonstrated in its comments that there is an insignificant

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22 See CellularVision comments at 3B.

23 See "LMDS is Not Viable in the Frequency Bands Above 40 GHz", Appendix 2 to the CellularVision comments.

24 Notice of Proposed Rulemaking, Order, Tentative Decision and Order on Reconsideration, CC Docket No. 92-297, Released January 8, 1993 at 63 and 65.

25 CellularVision comments at 3A.

difference in availability of a Suite 12 LMDS design in New York City when the frequency increases from 28 GHz to 41.5 GHz[26].

New York lies in Crane rain climatic region D_2. A large part of the United States lies either in rain climatic region D_2 or in regions having less severe rain climates. However, there are parts of the southeastern United States that lie in the more severe rain climatic regions of D_3 and E. The maximum cell size is markedly reduced in these regions for an LMDS system at 28 GHz. We have calculated the comparative performance of LMDS at 41.5 GHz and at 28 GHz in these regions. At 28 GHz, the cell size must be reduced to a radius of 2 miles and 1.2 miles in rain regions D_3 and E, respectively, in order to maintain the availability of 99.9% that the CellularVision system can achieve in New York. At 41.5 GHz, the comparable availability is 99.84% in rain climatic region D_3 and 99.86% in rain climatic region E. Thus, rain attenuation has been shown not to be a barrier to implementation of LMDS in the 40.5-42.5 GHz band anywhere in the United States. We would note that the same conclusion also applies to Europe where rain climates are no worse and in general correspond to regions where point rain rates are lower than in the United States.

When we performed our calculations, we assumed that the transmitter power of the LMDS hubs and subscribers remained the same as at 28 GHz as did the cell sizes and the physical aperture size of the LMDS antennas. Because antenna gain of a given aperture increases with frequency, no increase in the number of hub transmitters would be required due to

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26 The NASA comments showed, at II, that the availability of a Suite 12 LMDS system having a cell size of 4.8 km in New York City decreases by an insignificant amount from 99.9% to 99.84%.

propagation effects. A survey of numerous hardware manufacturers confirms that hardware performance which equals or exceeds that specified for the Cellular Vision design at 28 GHz is readily achievable at 41 GHz.

Availability and cost of components

There are only a few components that need to be changed to build an LMDS system at 41 GHz instead of at 28 GHz. For one-way distribution of video signals the RF sections of the hub transmitter and the subscriber receiver must be modified as do the hub and subscriber antennas. For two-way communications, the RF sections of the subscriber transmitter and the hub receiver would also be modified. The major expense components such as the baseband hub equipment, towers, buildings and real estate would not be affected.

The comments provided to the Commission by many of the elite microwave technology companies in the United States today should be convincing proof that components are available for LMDS implementation at 40 GHz. In addition, NASA has contacted a number of suppliers of microwave components in order to provide additional information regarding availability and cost.

Based on our inquiries and our own expertise, we offer the following information.

We believe that the availability of Traveling Wave Tube (TWT) transmitters is quite limited today at 28 GHz. We are unaware of TWTs specifically